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THE CHOLINESTERASE-POSITIVE PAPILLARY NERVE END-ORGAN IN THE SKIN OF SUBHUMAN PRIMATES*

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TABLE I

The subhuman primates studied

Prosimians
- Tupaioids
  - *Tupaia glis* (tree shrew)
- Lemuroids
  - *Lemur macaco* (black lemur)
  - *Lemur mongoz* (mongoose lemur)
  - *Lemur catta* (ring-tailed lemur)
  - *Lemur fulvus* (fulvus lemur)
- Lorisoids
  - *Loris tardigradus* (slender loris)
  - *Nycticebus coucang* (slow loris)
  - *Arctocebus calabarensis* (angwantibo)
  - *Perodicticus potto* (potto)
  - *Galago demidovii* (pigmy bushbaby)
  - *Galago senegalensis* (lesser bushbaby)
  - *Galago crassicaudatus* (great bushbaby)
- Tarsioids
  - *Tarsius syrichta* (Philippine tarsier)

New World Monkeys
- Haploids
  - *Tamarinus nigricollis* (black-collared tamarin)
  - *Tamarinus midas* (red-handed tamarin)
  - *Oedipomidas oedipus* (cottontop pinche)
  - *Oedipomidas spixi* (Spixi' pinche)
- Pithecoids
  - *Aotus trivirgatus* (owl monkey)
  - *Cacajao rubicuncus* (red uarkari)
  - *Pithecia monachus* (silvered sakiwinki)
  - *Saimiri sciurea* (squirrel monkey)
- Ceboids
  - *Cebus capucinus* (white-throated capuchin)
  - *Cebus apella* (black-capped capuchin)
  - *Ateles geoffroyi* (golden spider monkey)
  - *Lagothrix lagotricha* (woolly monkey)
  - *Alouatta caraya* (howler monkey)

Old World Monkeys
- Cercopithecoids
  - *Macaca irus* (crab-eating macaque)
  - *Macaca nemestrina* (pig-tail macaque)
  - *Macaca speciosa* (stump-tail macaque)
  - *Macaca fuscata* (Japanese macaque)
  - *Macaca mulatta* (rhesus monkey)
  - *Macaca silenus* (lion-tailed macaque)
  - *Papio anubis* (anubis baboon)
  - *Papio cynocephalus* (yellow baboon)
  - *Mandrillus sphinx* (mandrill)
  - *Cynopithecus niger* (Celebes ape)
  - *Cercopithecus neglectus* (DeBrazza's guenon)
  - *Cercopithecus aethiops* (green monkey)
  - *Cercipithecus mitis* (Sykes' monkey)
  - *Cercopithecus mona* (Mona monkey)
  - *Erythrocebus patas* (patas monkey)
  - *Cercocebus fuliginosus* (sooty mangabey)
  - *Cercocebus atys* (white-crowned mangabey)
- Coloboids
  - *Presbytis pyrrus* (lutong)
  - *Presbytis entellus* (Hanuman langur)

Apes
- Simioids
  - *Hylobates hoolock* (white-browed gibbon)
  - *Pongo pygmaeus* (orangutan)
  - *Pan satyrus* (chimpanzee)
  - *Gorilla gorilla* (gorilla)

The study of cutaneous nerve endings has engaged the attention of numerous investigators for more than 200 years (1). Here are some of the end-organs described: the Vater-Pacini corpuscle (2), tactile disks (3), the hair follicle nerve end-organ (4), Krause's end-bulbs (5), genital corpuscles (6), mucocutaneous end-organs (7, 8), Meissner's corpuscles (9), Herbst's corpuscle (10), Golgi-Mazzoni

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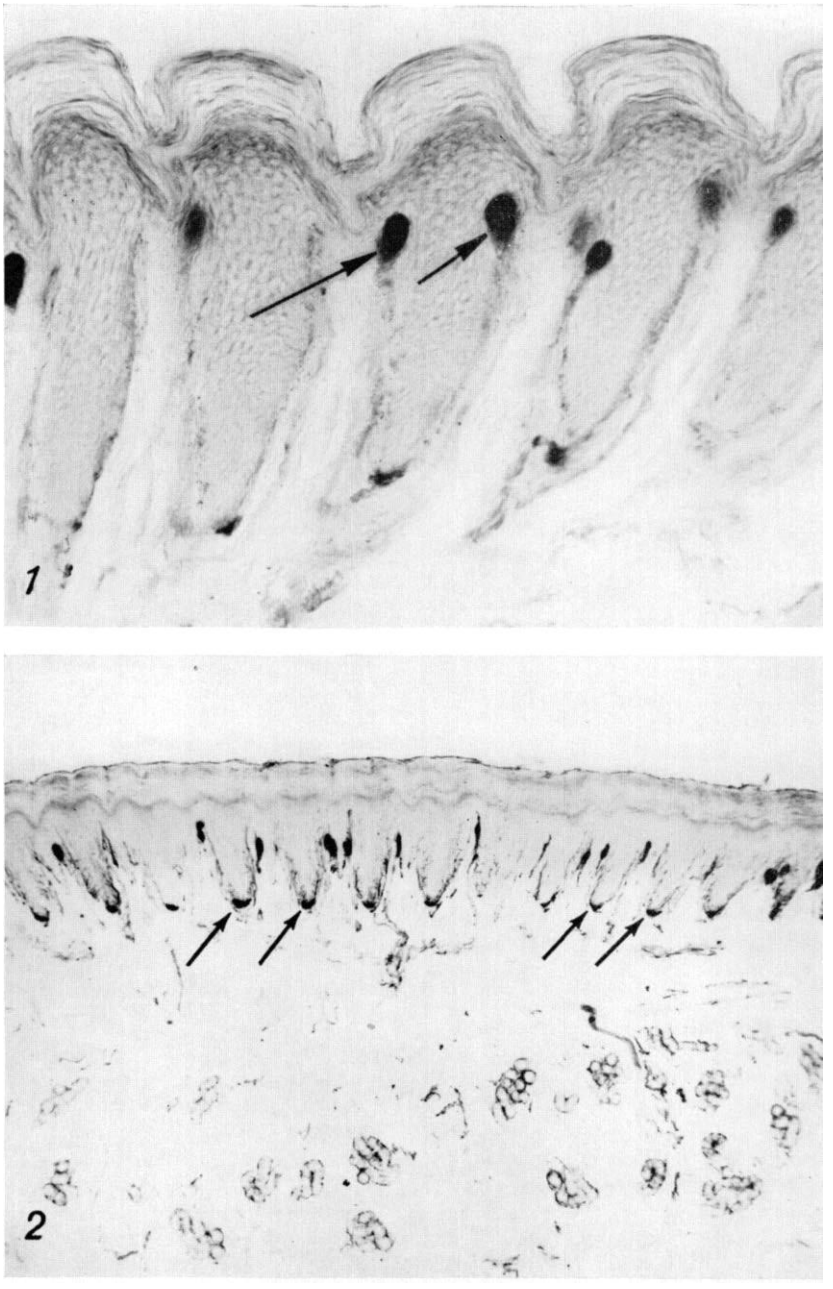

FIG. 1. Section from the fingerball of Philippine tarsier showing butyrylcholinesterase-rich papillary nerve end-organs at the base of the epidermal ridges which receive nerve fibers from the Meissner-like corpuscles (arrows). ca. × 190.

FIG. 2. Frozen section from the fingerball of white-crowned mangabey showing Meissner corpuscles and papillary nerve end-organs only at the base of intermediate ridges (arrows). In the lower half the eccrine sweat glands are surrounded by nerve fibers which contain butyrylcholinesterase. ca. × 25.

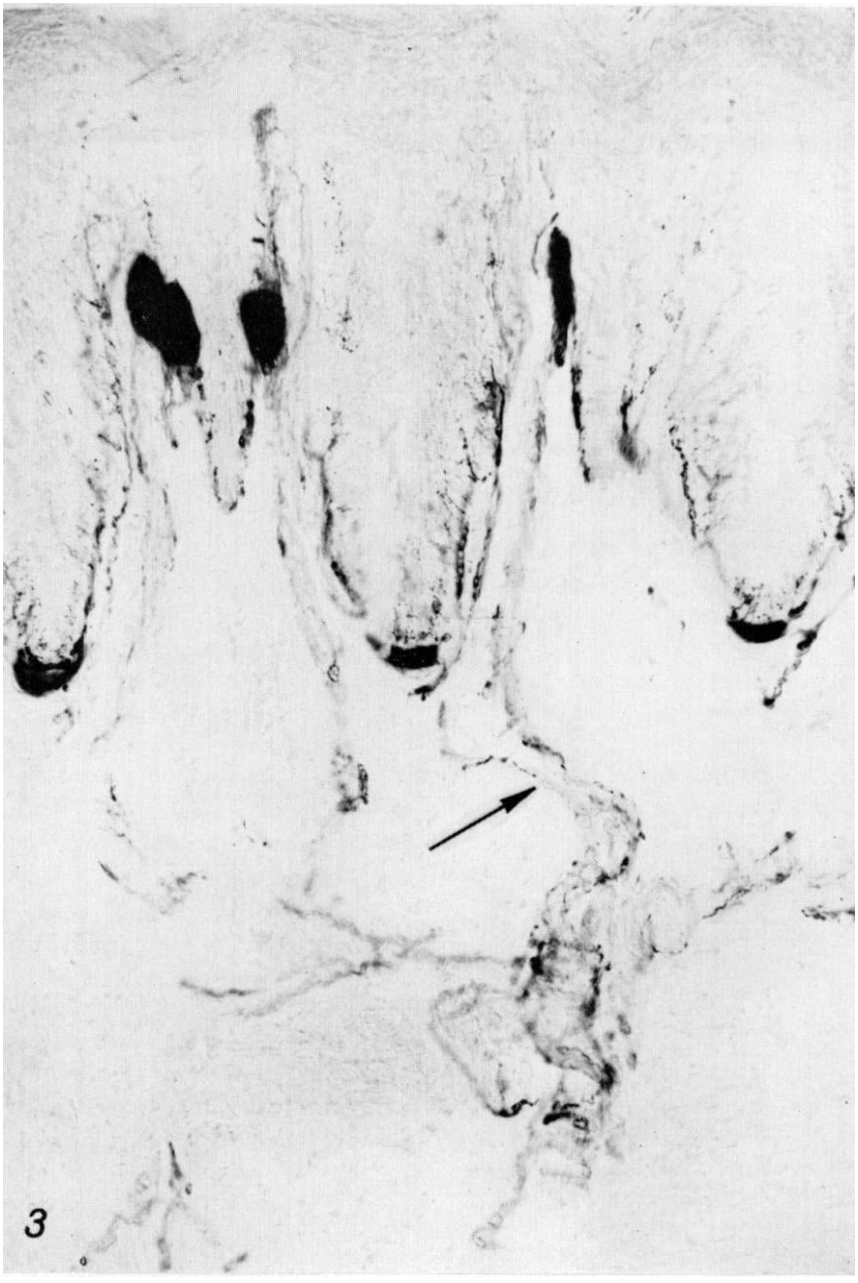

FIG. 3. Cross-section from the fingerball of white-crowned mangabey showing both Meissner corpuscles and flattened papillary nerve end-organs. Cholinesterase-reactive nerve fibers which emerge from these papillary nerve end-organs join with those coming from the Meissner corpuscles to form large myelinated nerve fibers (arrow). ca. × 200.

bodies (11, 12), Ruffini bodies (13), and others.

To this partial listing we add the *papillary nerve end-organ,* a structure rich in cholinesterase, localized at the base of the epidermal ridges in the friction surfaces of the white-crowned mangabey (*Cercocebus atys*) (14), stump-tail macaque (*Macaca speciosa*) (15),

TABLE II

Comparison of this end-organ and Meissner's corpuscle

	Meissner's corpuscle	This end-organ
Presence in the animals	All species studied	5 species
Location	In the dermal papilla	At the base of epidermal ridges
Form	Circular or oval	Flat
Size	Larger	Smaller
Number of nerve fibers to each corpuscle	9 (after Winkelmann, 1960)	1
Structure of nerve fibers in the corpuscle	Coil, spiral or loop	Linear
Function	Touch sensation	Touch sensation

Philippine tarsier (*Tarsius syrichta*) (16), squirrel monkey (*Saimiri sciurea*) and silvered sakiwinki (*Pithecia monachus*).

MATERIALS AND METHODS

Skin samples from the friction surfaces of the pes and manus of 49 species of primates were collected fresh (Table I). The specimens were fixed in 10% chilled neutral formalin and treated for acetyl- and butyrylcholinesterase (17) and with the silver impregnation of Winkelmann and Schmit (18).

RESULTS

Five of the 49 species of primates studied—the mangabey (*Cercocebus atys*), stump-tail macaque (*Macaca speciosa*), tarsier (*Tarsius syrichta*), squirrel monkey (*Saimiri sciurea*), and silvered sakiwinki (*Pithecia monachus*)—have butyrylcholinesterase-rich nerve end-organs at the base of the epidermal ridges in the fingerball. Unlike Meissner corpuscles, which are nestled in the dermal papillae between the epidermal ridges, these flattened, small nerve end-organs are arranged regularly at the base of the epidermal ridges. In four of the five species the nerve end-organs are present only at the base of some of the ridges (Fig. 1); only in the mangabey are they present in every ridge (Fig. 2).

The cholinesterase-reactive nerve fibers which emerge from these end-organs join with those coming from the Meissner corpuscles to form large myelinated nerve fibers (Fig. 3). Only one silver-impregnated nerve fiber can be seen issuing from each end-organ, in contrast with the Meissner corpuscles from which issue several afferent nerve fibers (19). Other comparisons of this end-organ with Meissner's corpuscle are tabulated in Table II.

DISCUSSION AND SUMMARY

At the base of the epidermal ridges in the friction surface of human hands and feet are flattened hederiform terminations, or Merkel's disks (20), that somewhat resemble the end-organs described herein. Only 5 of the 49 species of primates studied have the small, flat, cholinesterase-rich nerve end-organs at the base of the epidermal ridges in friction surfaces. Although it is not possible to be sure of its function, this end-organ, together with Meissner's corpuscle, may be associated with tactile sensibility.

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